



Energy Technologies Area

Lawrence Berkeley National Laboratory

# The Cost of Saving Electricity Through Energy Efficiency Programs Funded by Utility Customers: 2009–2015

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Summary - June 2018

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# Overview

- Why the cost of saving electricity (CSE) matters
- LBNL cost of saving electricity project
  - Data and analytical approach and program typology
  - What's in the database – program spending and lifetime savings by market sector
  - Definitions
- Program administrator (PA) CSE results
  - National, regional and market sectors
  - Select residential and commercial & industrial (C&I) programs
  - Trends
  - Electricity efficiency cost curve
- Disaggregating costs: Administration and marketing costs as share of PA costs
- Total CSE results
  - National, regional and market sectors
  - Select residential and C&I programs
  - Trends
- Discussion and future research directions

# Why the cost of saving electricity matters

- To help ensure electricity system reliability at the most affordable cost as part of resource adequacy planning and implementation activities
  - Increasing role of efficiency as an energy and capacity resource, driven in part by state policies
  - Spending on utility customer-funded programs grew ~20% from 2011-2016\*
  - Declining costs for some supply-side resources sharpens discussion of type and market share of clean energy investments
- To project efficiency's impact on electricity load forecasts
- To benchmark program results with regional and national estimates
- For initial screening of electricity resource alternatives
- To evaluate how program costs are likely to change over time with funding levels and participation

\*Consortium for Energy Efficiency (2018). [2017 State of the Efficiency Program Industry: Budgets, Expenditures, and Impacts](#)

# LBNL Cost of Saving Electricity Project: Data and Analytical Approach

## Approach

- Collect & analyze reported annual energy efficiency (EE) program data

## LBNL DSM Program Database

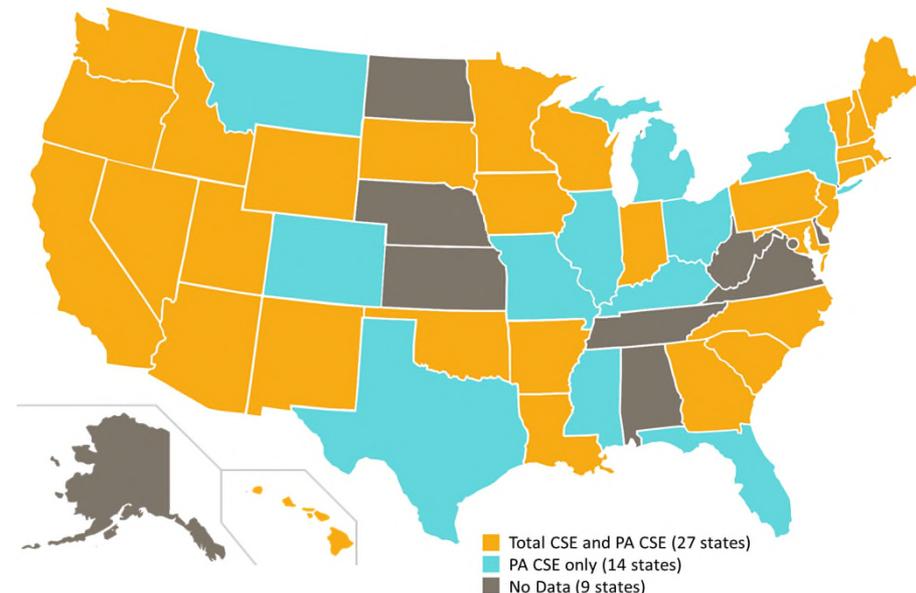
- Program Administrator CSE: 116 electricity EE administrators in 41 states
  - N = 8,790 program years (2009-2015)
- Total Cost of Saved Electricity: 67 administrators in 27 states
  - N = 4,590 program years

## Data Collected

- Annual & lifetime savings
- Budgets & expenditure details
- Measure lifetimes for programs
- Participation

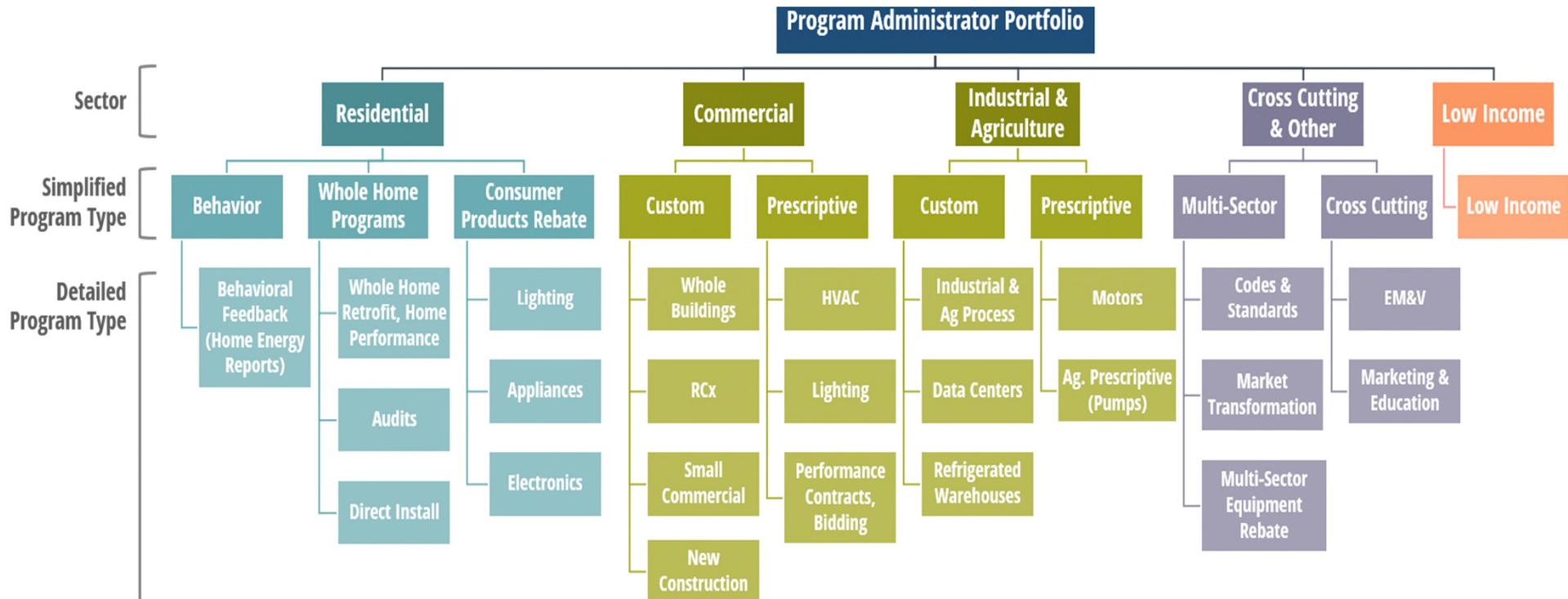
## Standardization Is Critical

- A common DSM lexicon and program typology
- LBNL program reporting tools for:
  - Investor-owned utilities
  - Public power utilities



# LBNL Efficiency Program Typology

- Characterizes programs by market sector, technologies and delivery approaches
  - Reflects range of reporting detail and enables multiple levels of analysis
- Six sectors, 27 simplified programs and >60 detailed program types



See LBNL brief, [Energy Efficiency Program Typology and Data Metrics: Enabling Multi-State Analyses Through the Use of Common Terminology](#)

*\*Figure is illustrative. Not all program types are depicted.*

# LBNL Energy Efficiency Reporting Tools

## FOR MID-SIZED/EARLY STAGE PROGRAM ADMINISTRATORS

- [Full-featured DSM reporting tool](#) for PAs for programs funded by utility customers
  - Flexible to accommodate the diverse data requirements in states while maintaining reporting consistency
  - Program-level spending, savings, participation, cost-effectiveness and program design
  - Screening questions allow PA or PUC to customize information that is to be reported
  - Includes data glossary and program typology
- [Reporting tool for public power](#)

ABC Utility

insert program administrator logo here

Standardized Annual Reporting Workbook v1.0 September 2015

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**STEP ONE: Complete Program Administrator (PA) Information**

**Instructions**

Program Administrator Name: ABC Utility

Program year being reported: 2014

Program year definition: EE proceeding docket #

Date EE docket was filed:

Name of Contact:

Email Address:

Telephone Number:

**Data Glossary**

Single or Multi Fuel Utility: Single Fuel

Utility Fuel Type Reported: Electric

2014 EE Savings Target Format: Gross Energy Savings

2014 EE Gross Savings Target (MWh): 200

Target baseline retail sales (MWh): 28,800

Source of target baseline retail sales:

Portfolio, Reporting & Other Notes

[Click to Add Notes](#)

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**STEP TWO: Answer screening questions**

Answer these questions to help establish your minimum reporting requirements and desired outputs

<p>1) How do you report your savings?</p> <p><input checked="" type="radio"/> Net &amp; Gross</p> <p><input type="radio"/> Gross Only</p> <p>1b) Do your reported gross savings values account for naturally occurring energy savings?</p> <p><input type="radio"/> Yes</p> <p><input checked="" type="radio"/> No</p> <p>2) What level are your programs screened for cost-effectiveness for regulatory purposes?</p> <p><input type="radio"/> Customer sector &amp; Portfolio</p> <p><input checked="" type="radio"/> Program</p> <p>3) What cost effectiveness tests do you provide in your annual report? Select all that apply</p> <p><input checked="" type="checkbox"/> Total Resource Cost Test</p> <p><input checked="" type="checkbox"/> Program Administrator Cost Test</p> <p><input type="checkbox"/> Societal Cost Test</p> <p><input type="checkbox"/> Ratepayer Impact Measure Test</p>	<p>4) Do you want to compare actual expenditures and claimed savings with planned values?</p> <p><input type="radio"/> Yes</p> <p><input checked="" type="radio"/> No</p> <p>5) Are you also reporting evaluated savings?</p> <p><input type="radio"/> Yes</p> <p><input checked="" type="radio"/> No</p> <p>6) Are you comparing spending and savings for this program year with previous program years?</p> <p><input type="radio"/> Yes</p> <p><input checked="" type="radio"/> No</p> <p>7) Do you report savings at site or savings at the site plus T&amp;D losses between site and the power plant?</p> <p><input type="radio"/> Site</p> <p><input checked="" type="radio"/> Site plus T&amp;D losses</p>	<p>8) Do you account for interactive effects in your reported savings values? (see glossary for definition)</p> <p><input checked="" type="radio"/> Yes</p> <p><input type="radio"/> No</p> <p>9) Do you have an energy efficiency program that allows customers to finance projects?</p> <p><input type="radio"/> Yes</p> <p><input checked="" type="radio"/> No</p> <p>10) Do you report a claimed program administrator incentive?</p> <p><input type="radio"/> Yes</p> <p><input checked="" type="radio"/> No</p>
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**STEP THREE: Data Inputs**

Common to all Program Administrators

a) Program Details & Descriptions

b) Claimed Program Savings

c) Actual Program Expenditures

d) Cost-effectiveness Test Results

e) Key Assumptions

Reporting features specific to ABC Utility

Available features depend on answers in Step Two

**STEP FOUR: Data Outputs**

Table 1: Portfolio Savings, Expenditures, Cost Effectiveness, Goals & Assumptions

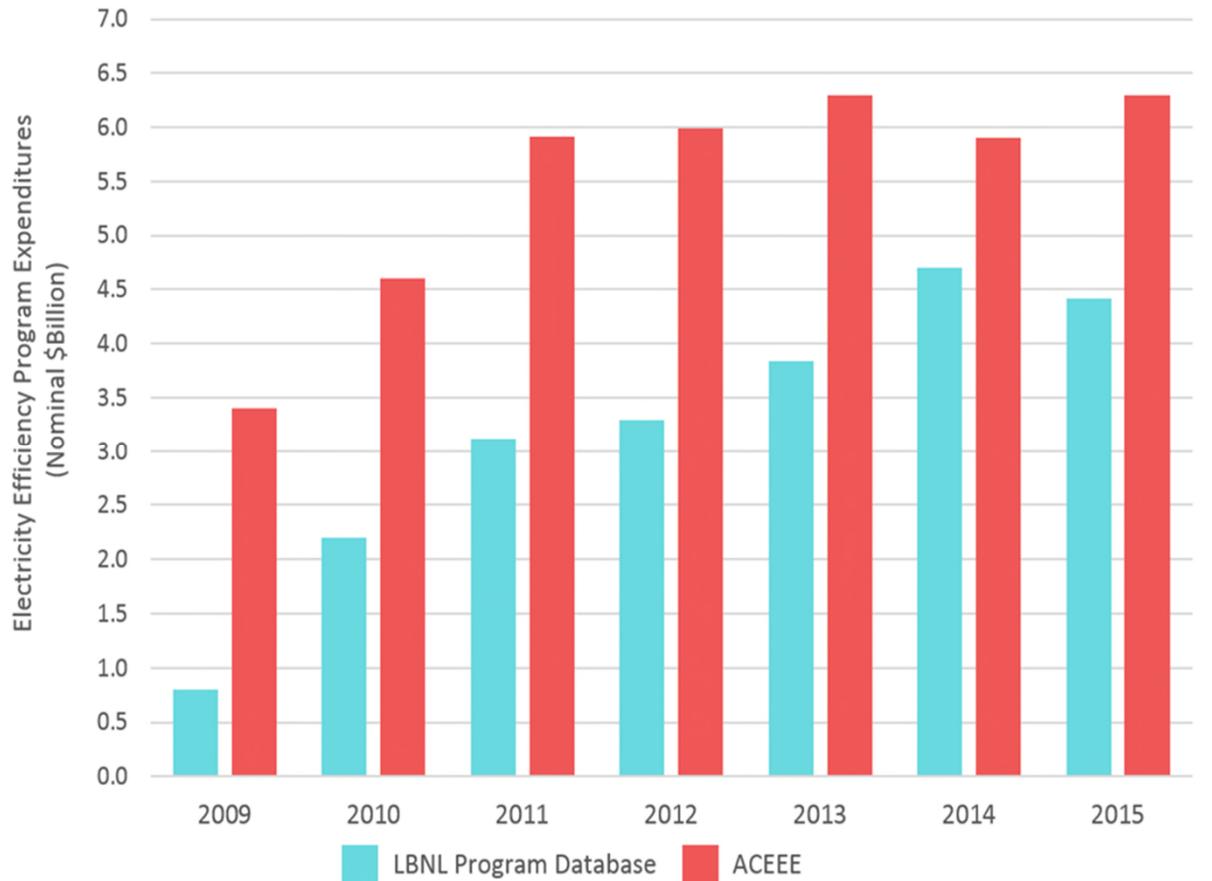
Table 2: Market Sector Savings, Expenditures and Cost Effectiveness

Table 3: Spending by Program

Table 4: Portfolio Summary by Expenditure Type

Table 5: Results Detailed by Program

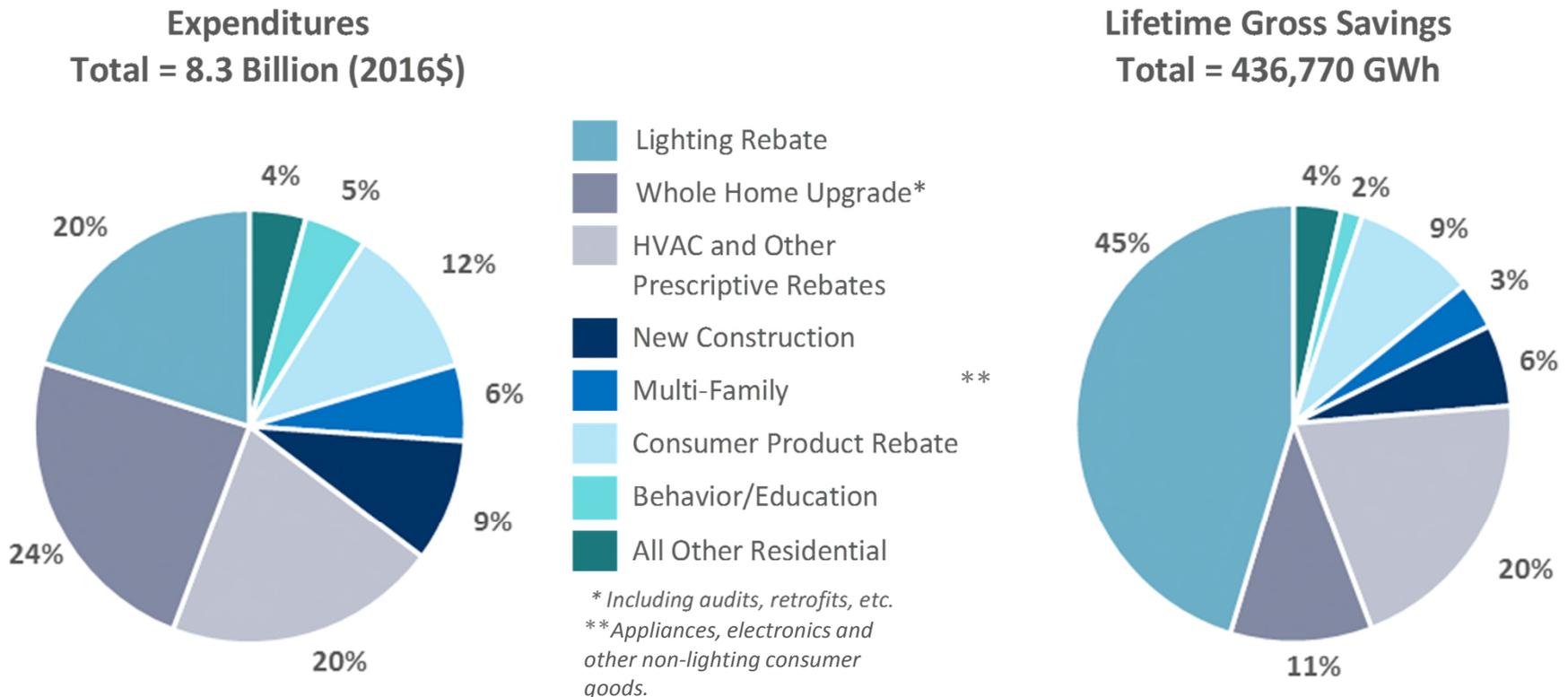
# LBNL database includes 70-80% of national spending on electricity efficiency programs



- LBNL's database covers a large and increasing share of national electricity efficiency program spending
  - 80% of spending for all utility programs in 2014 (including public power utilities), up from 24% in 2009
  - 70% of spending in 2015

# Residential Program Spending and Lifetime Savings

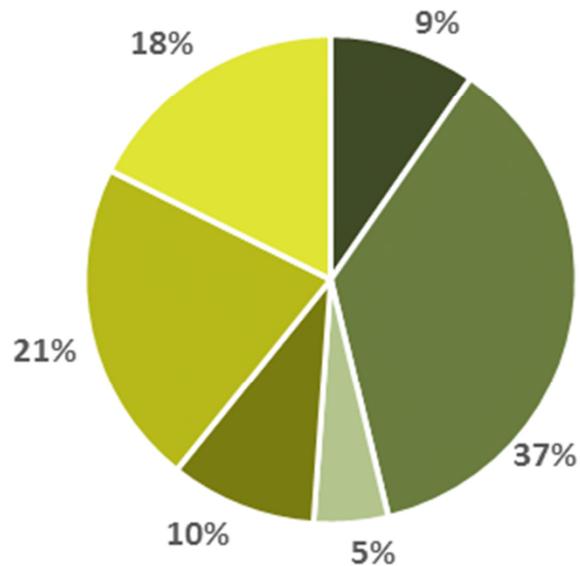
- \$8.3B in residential program spending from 2009 to 2015 in LBNL database
- Whole-home upgrades and prescriptive rebates together account for 44% of spending and 31% of lifetime savings
- Lighting rebate programs account for 20% of spending and 45% of lifetime savings



# C&I Program Spending and Lifetime Savings

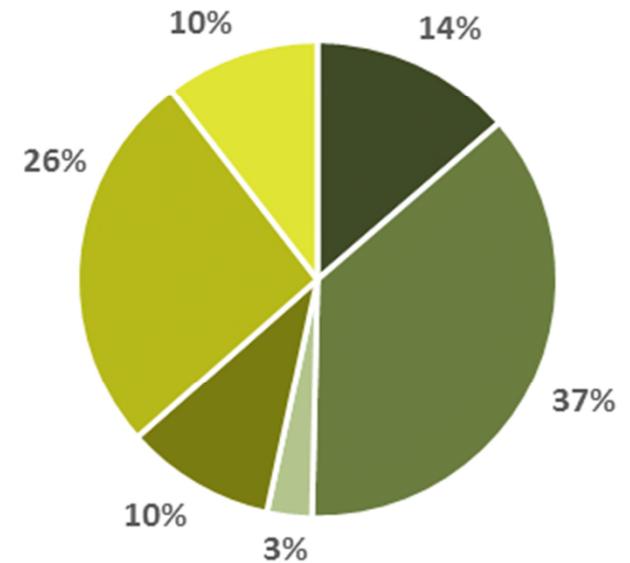
- \$13.4B in C&I program spending from 2009 to 2015 in LBNL database
- Custom rebate, prescriptive rebate, and small commercial programs account for about 3/4 of spending and lifetime savings

**Expenditures**  
Total = 13.4 Billion (2016\$)



\* Municipal/state governments, universities, K-12 schools and hospitals

**Lifetime Gross Savings**  
Total = 836,241 GWh



# Definitions: PA and Total Cost of Saving Electricity

Levelized Program Administrator Cost of Saving Electricity (PA CSE)

The cost to the *program administrator* for achieving electricity savings over the economic lifetime of the actions taken, discounted back to when the costs were paid and the actions occurred

Levelized PA CSE for EE programs calculated using the following assumptions and inputs:

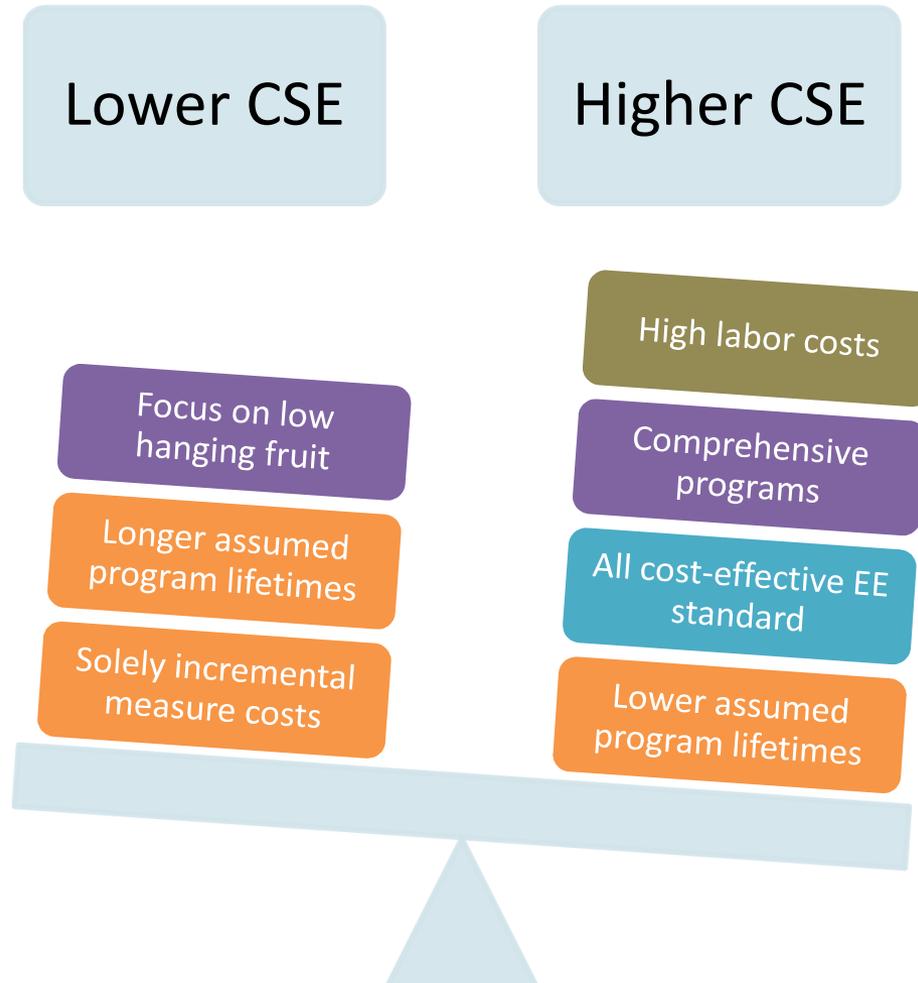
- 6% discount rate (real)
- Estimated program average measure lifetime
- Total program cost, including incentives (2016\$)
- Gross annual kWh saved

Levelized Total Cost of Saving Electricity (Total CSE)

The costs incurred by program administrators and participants for achieving electricity savings over the economic lifetime of the actions taken, discounted back to when the costs were paid. Participant costs are net of any incentives paid by the program.

# Influences on PA and Total CSE

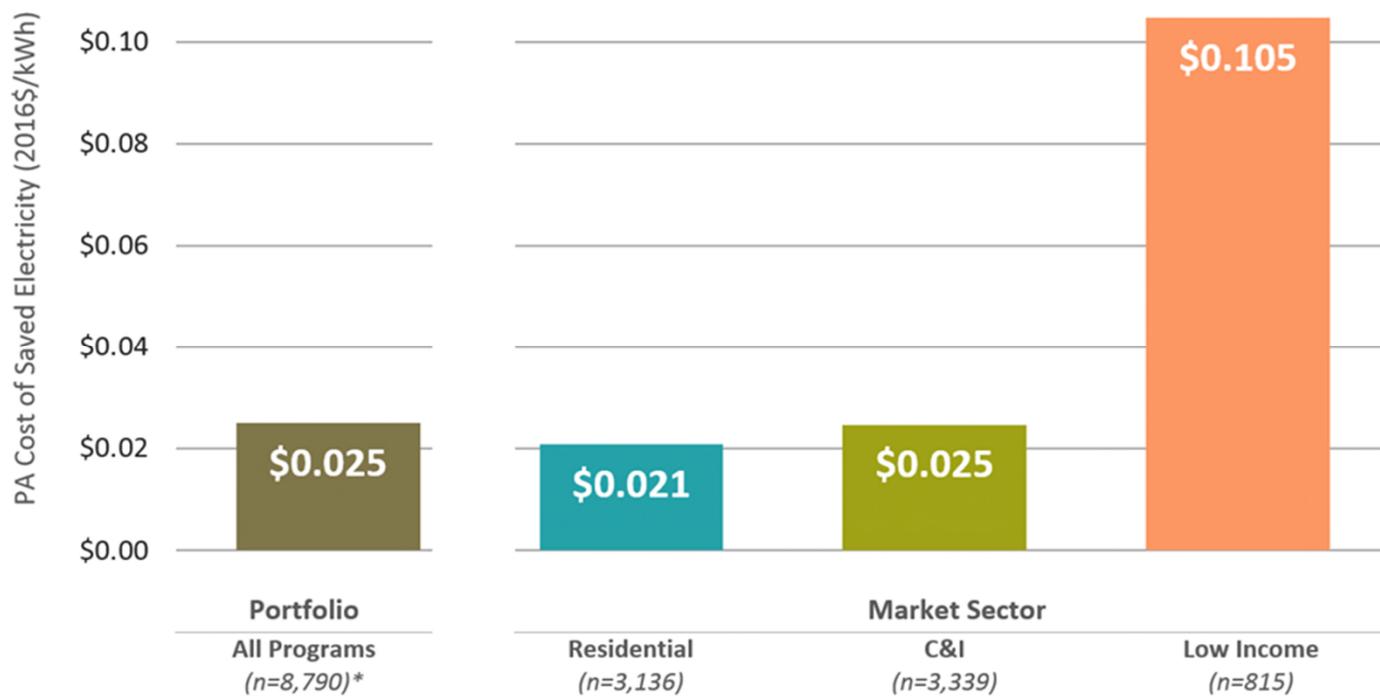
CSE may vary across program administrator portfolios for reasons other than programmatic efficiency



# Program Administrator Cost of Saving Electricity

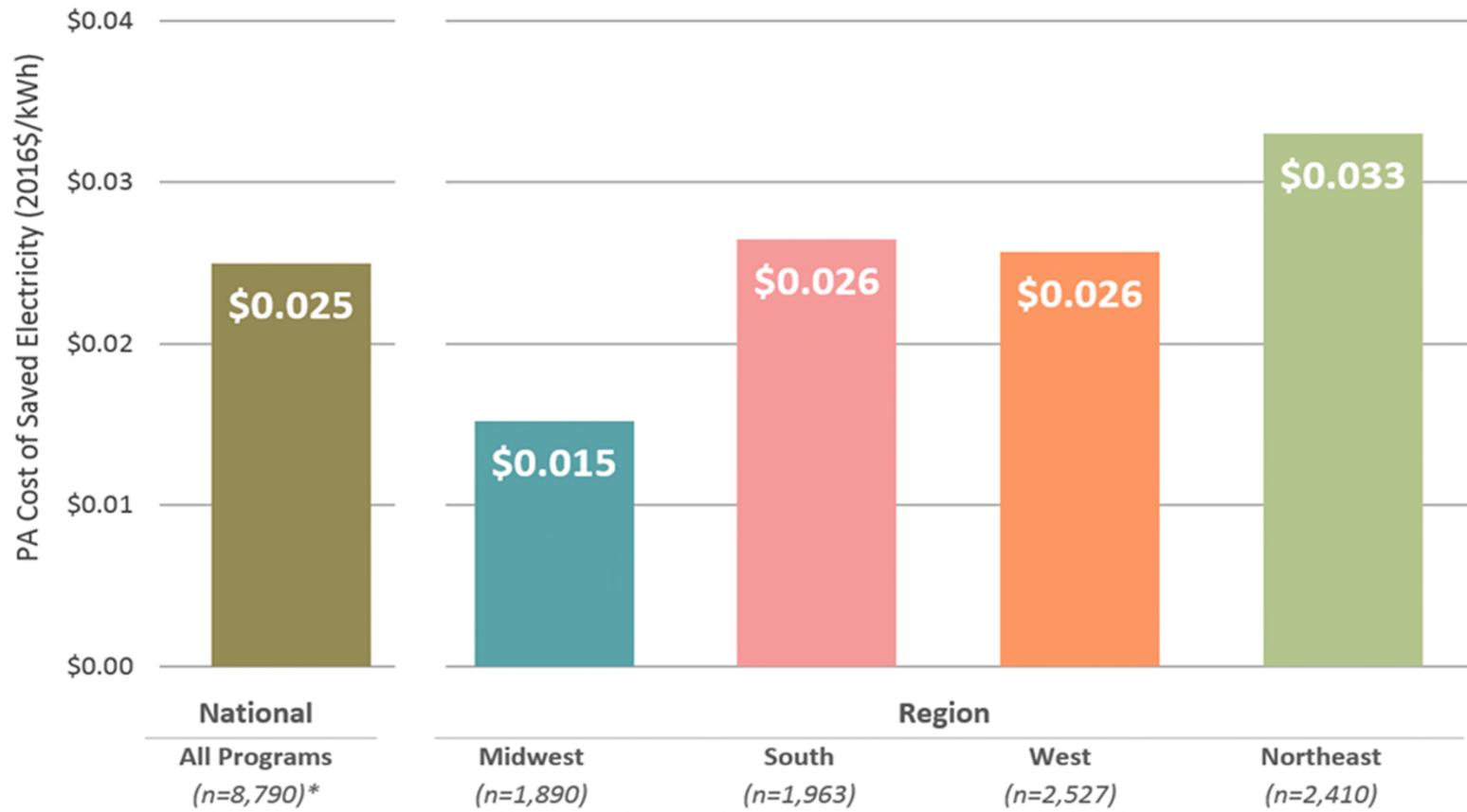
# Program Administrator Cost of Saving Electricity: National Results (2009-2015)

- U.S. savings-weighted average PA CSE for all programs: \$0.025/kWh (2009-2015)
- PA CSE for residential programs: \$0.021/kWh, influenced strongly by lighting rebate programs
- PA CSE for C&I programs: \$0.025/kWh
- PA CSE for low-income programs: \$0.105/kWh (account for 2% of savings, 9% of spending)

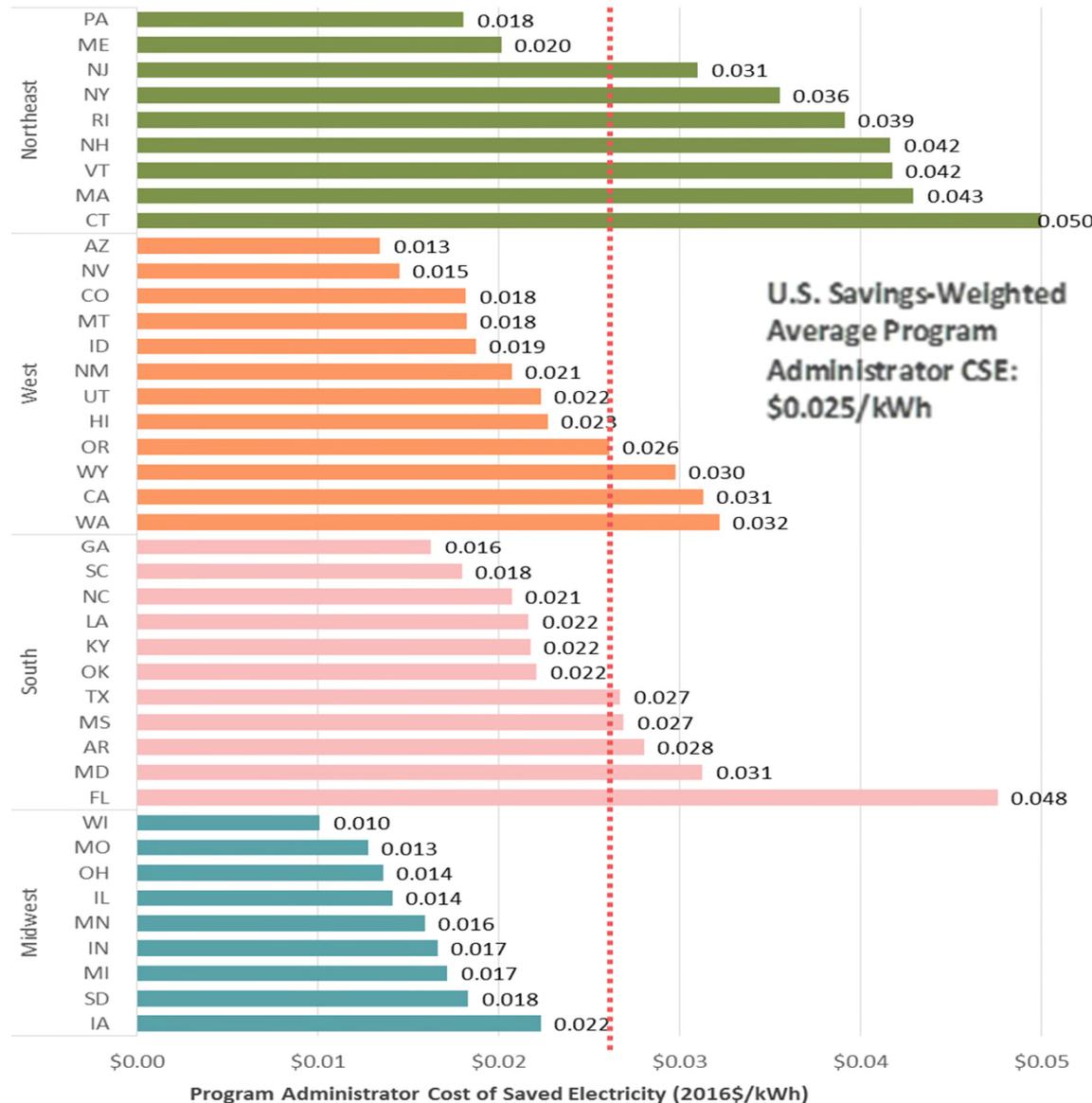


# Program Administrator Cost of Saving Electricity: Regional Results (2009-2015)

- Savings-weighted PA CSE varied widely across regions: \$0.015 to \$0.033/kWh
- Comparable CSE values in South and West: \$0.026/kWh
- Midwest markedly lower: \$0.015/kWh. Many Midwest states ramped up programs between 2009 and 2015, with significant investment in low-cost programs.



# Program Administrator Cost of Saving Electricity: State-level Results (2009-2015)



- 17 states with a PA CSE of  $\leq$ \$0.02/kWh, concentrated in the Midwest, South and Intermountain West
- PA CSE greater than \$0.04/kWh in five states. Four of these states (CT, VT, MA, and NH), in the Northeast, have relatively high electricity prices, extensive history with EE and strong policy commitments.

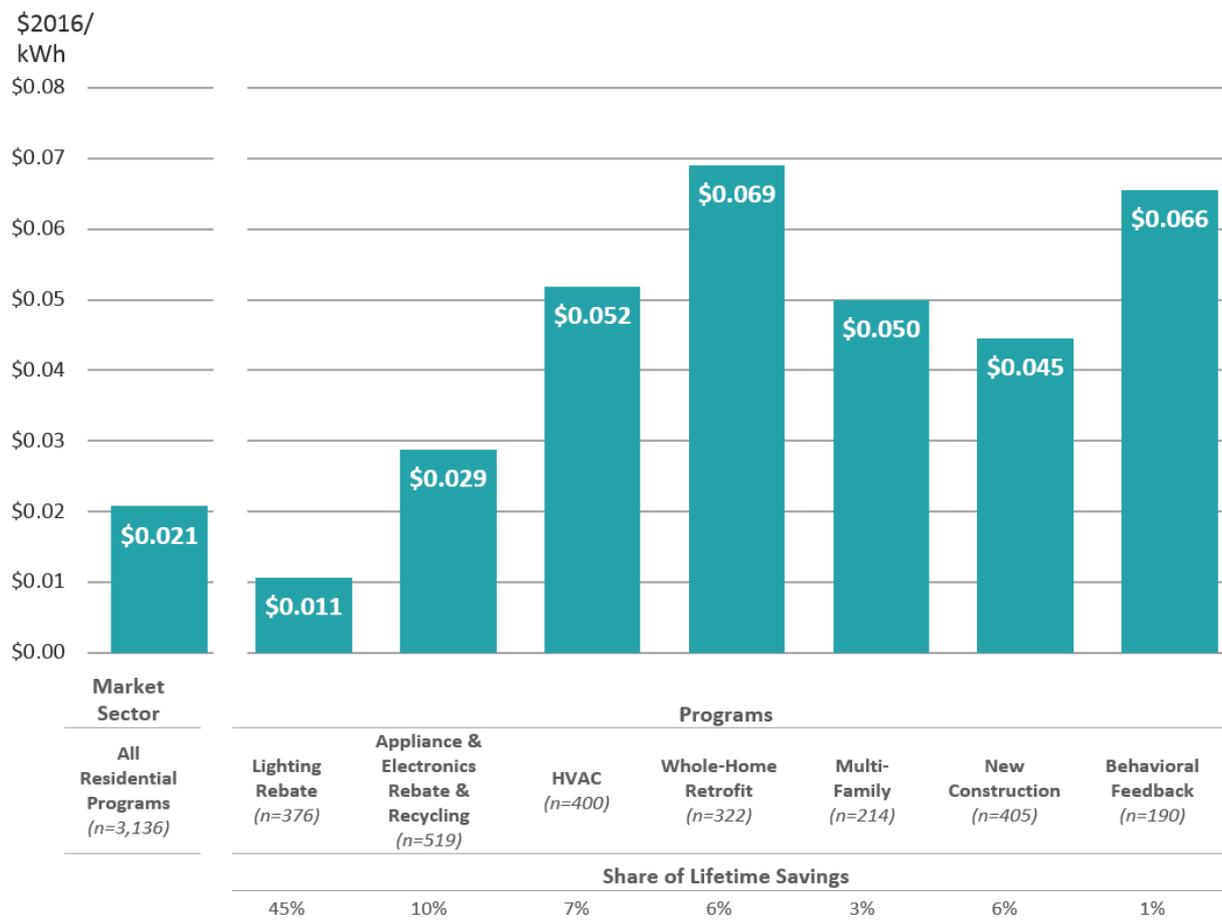
# Program Administrator Cost of Saving Electricity: State-level Results (cont.)



- 2015 electricity savings expressed as % of 2015 retail sales
- PA CSE values tend to be higher in states that achieve more aggressive savings levels. 23 states reported annual electricity savings  $\geq 1\%$  of retail sales
- Nine states in NE and West  $>1.5\%$  savings
- Four states with  $>2\%$  savings (ME, VT, RI, MA)

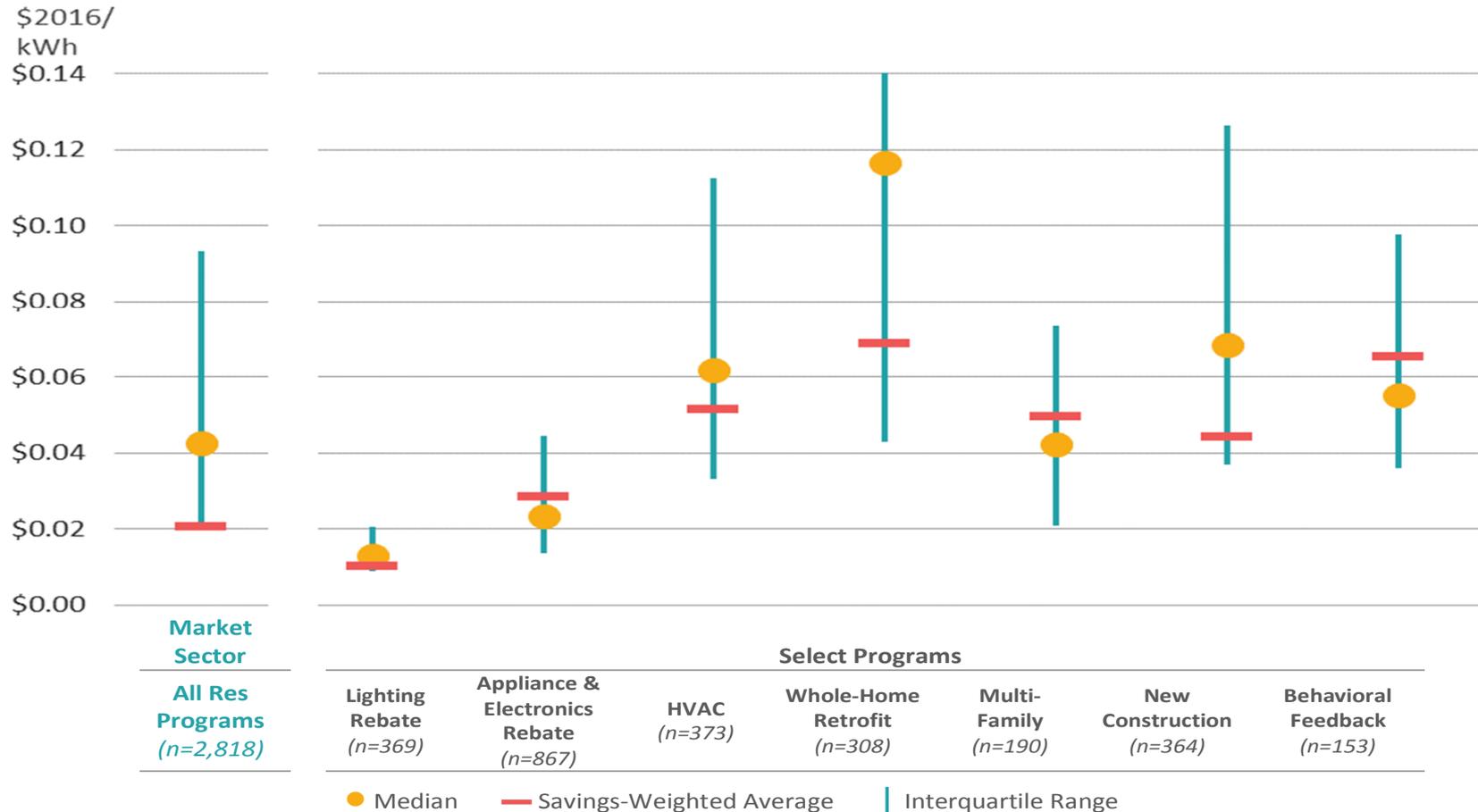
# Program Administrator Cost of Saving Electricity: Select Residential Programs

- Wide range in residential PA CSE across programs: six-fold difference from lighting rebates (\$0.011/kWh) to whole-home retrofits (\$0.069/kWh)
- Lighting and consumer product rebates provide low-cost savings that allow PAs to offer other programs that are higher cost, but more comprehensive



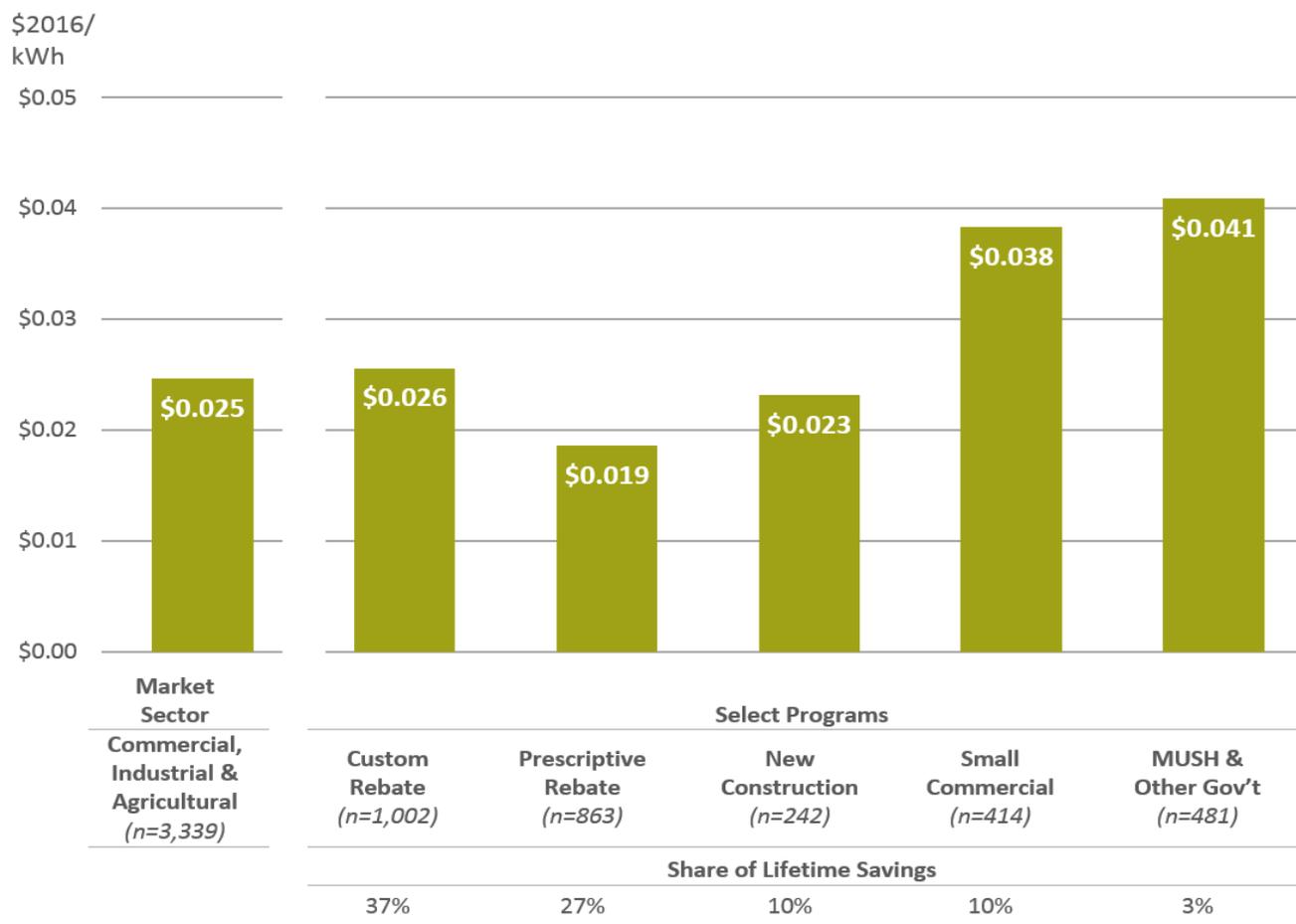
# Program Administrator Cost of Saving Electricity: Median Values and Ranges for Residential Programs

- Median PA CSE for residential sector: \$0.042/kWh
- Low variability in PA CSE for lighting vs. other programs (HVAC, whole home retrofit, new construction) where variability in CSE values is greater — reflects diversity in program design and mix of measures



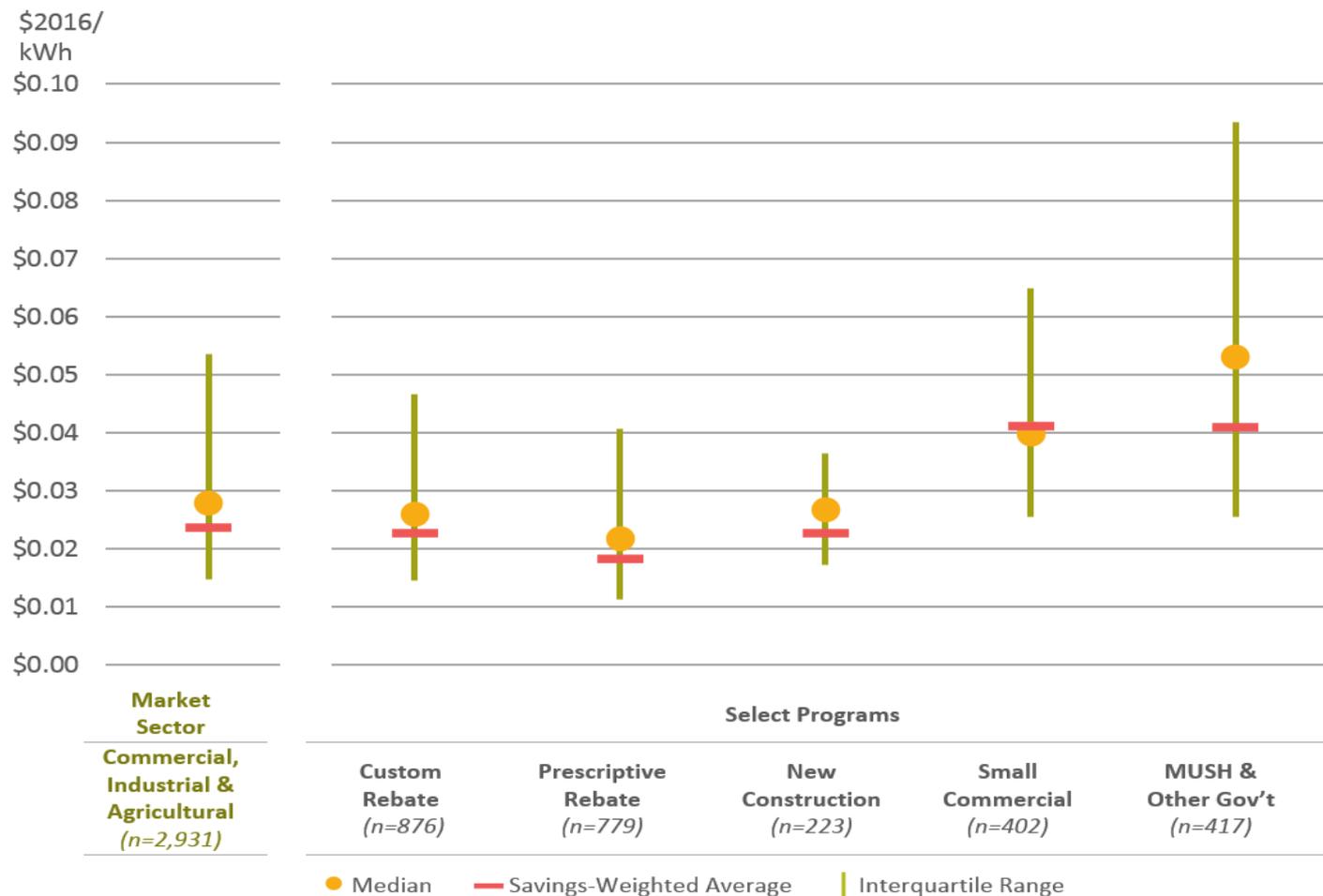
# Program Administrator Cost of Saving Electricity: Select C&I Programs

- Savings-weighted PA CSE for C&I programs with largest savings — custom, prescriptive rebates, and new construction: \$0.019/kWh to \$0.026/kWh
- Savings are more evenly distributed across C&I program types, and average CSE varies only by a factor of two



# Program Administrator Cost of Saving Electricity: Median Values and Ranges for C&I Programs

- Median PA CSE for C&I sector: \$0.028/kWh
- Lower variability in PA CSE values among major program types (e.g., range of 2.1 vs. 3.4 for C&I vs. residential new construction)



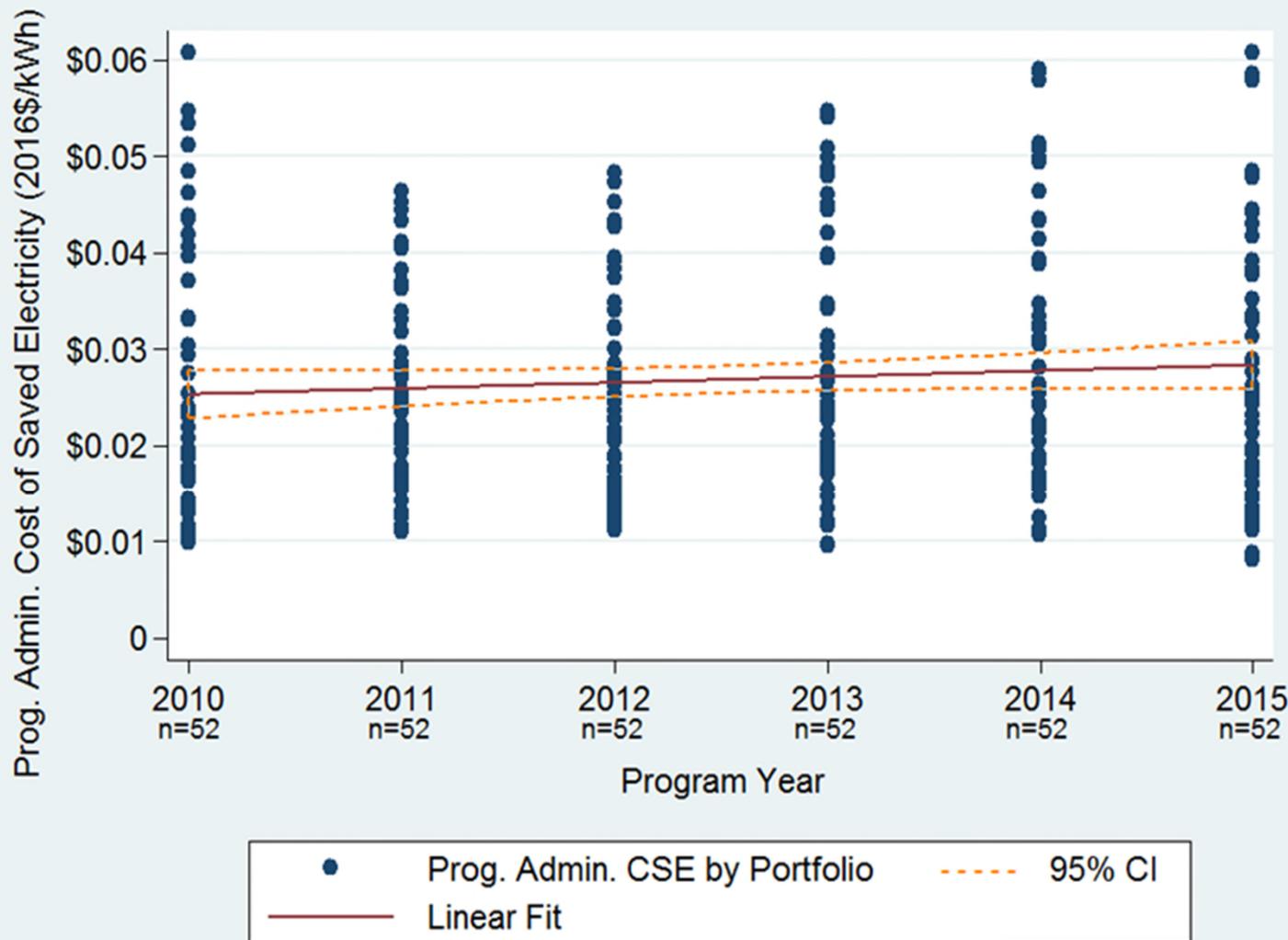
# Trends in the PA CSE: 2010-2015

- 51 PAs with continuous data for 2010-2015
  - Average PA CSE increasing over time
- Divided into three groups based on annual savings
  - Average CSE increasing over time for highest and middle group of annual savers (larger PAs); decreasing over time for lowest savers (smaller PAs)
  - Average CSE for *individual* PAs is rising for higher savers, flat for middle savers, declining for lower savers

PA Group	2010	2011	2012	2013	2014	2015	CAGR: Savings-Weighted Average	CAGR: Mean Value
All 51 PAs	\$0.022	\$0.025	\$0.024	\$0.025	\$0.028	\$0.026	3.5%	0.2%
Highest Third	\$0.021	\$0.026	\$0.023	\$0.023	\$0.027	\$0.025	3.5%	3.8%
Middle Third	\$0.020	\$0.023	\$0.021	\$0.030	\$0.029	\$0.028	7.0%	0.2%
Lower Third	\$0.032	\$0.026	\$0.027	\$0.029	\$0.033	\$0.031	-0.6%	-2.8%

CAGR = compound annual growth rate

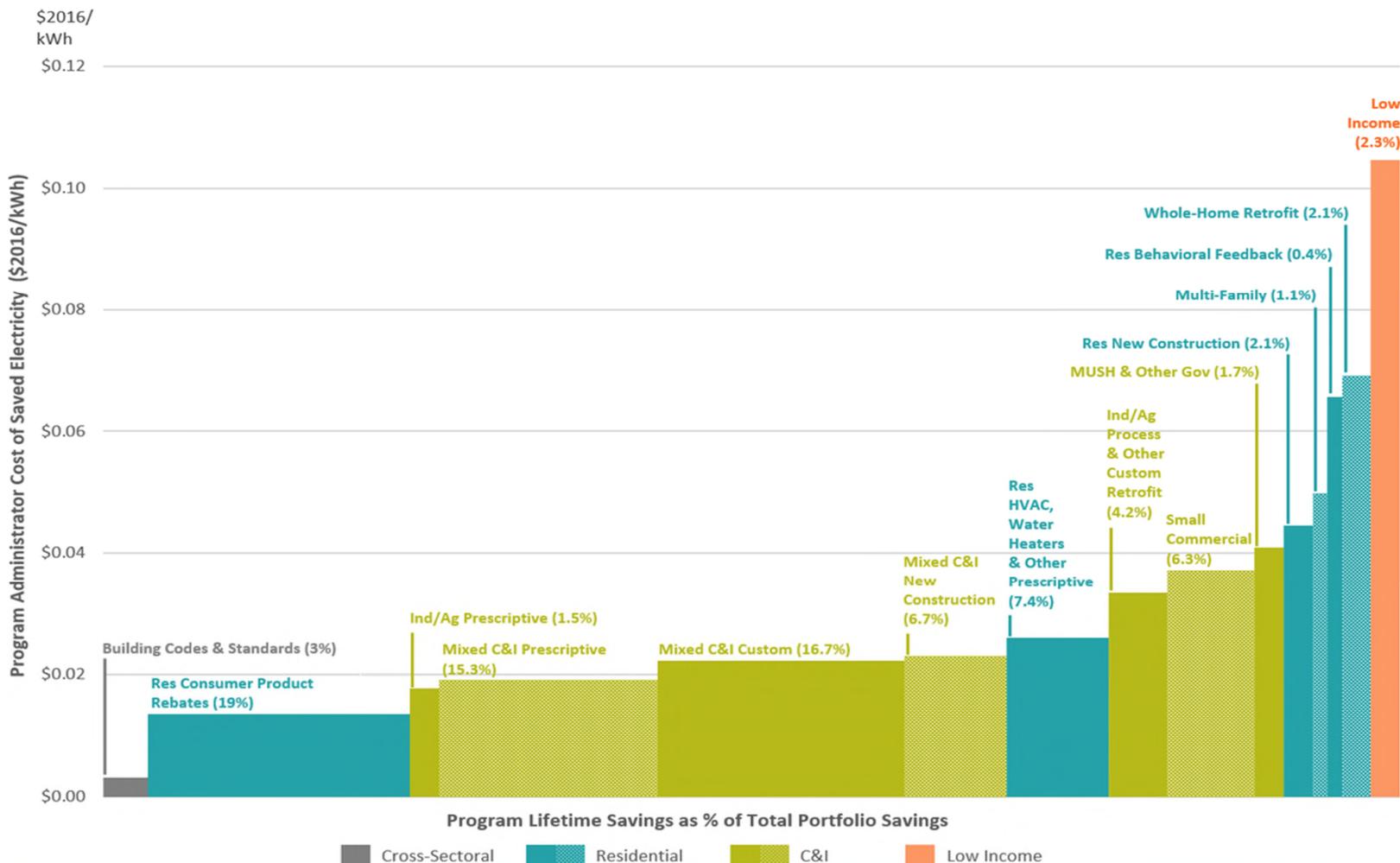
# Program Administrator Cost of Saving Electricity: 2010-2015 Trends in Acquisition Cost



- Balanced panel of 51 PAs with continuous data, 2010-2015
- More formal statistical measurement
  - Fitted across all years, not just beginning and end years
- Moderate rate of increase, ~2.5% per year

# Program Administrator Cost of Saving Electricity: Program Savings Cost Curve

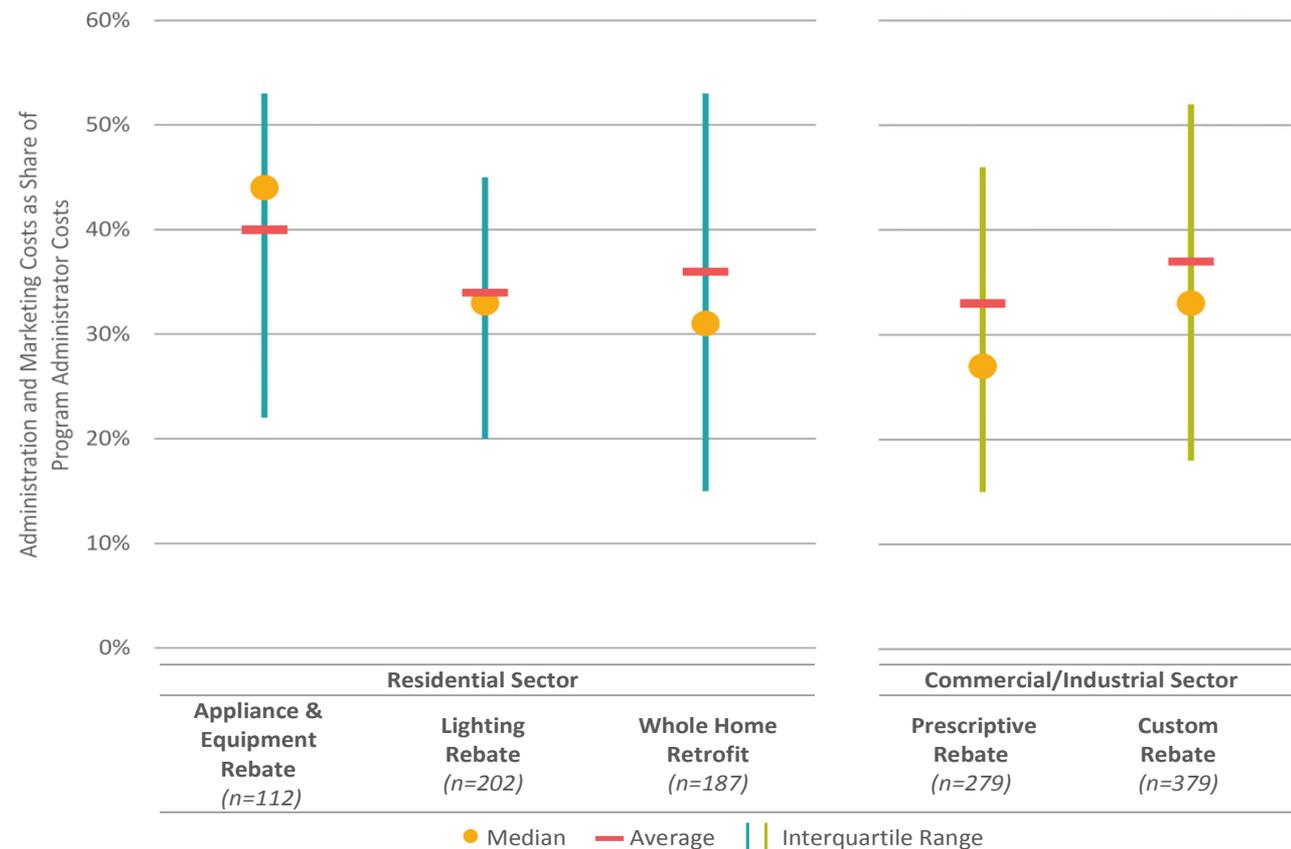
- Programs ordered by actual cost performance on x-axis; width scaled to represent lifetime savings
- Reinforces program analysis: Residential programs (blue) are least (and most) expensive; C&I programs (green) are steadier producers of savings



# Disaggregating Program Costs: Administration and Marketing Costs for Select Program Types

Median and average values for ratio of administration and marketing costs to overall PA costs:

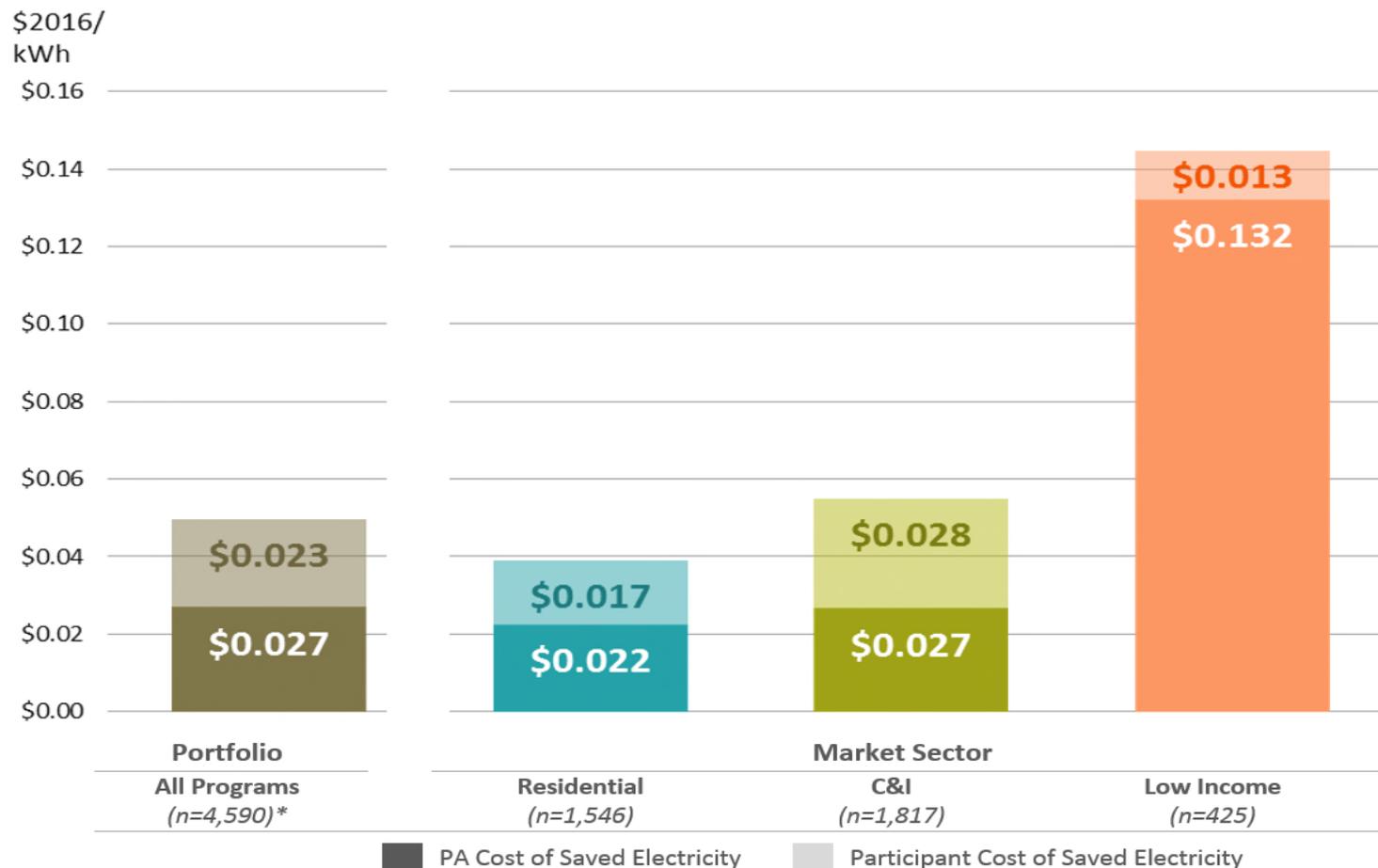
- Residential
  - 33% to 36% for lighting and whole home retrofit programs
  - >40% for appliance/equipment rebate programs
- Commercial
  - 27% to 37% for prescriptive and custom rebate programs



# Total Cost of Saving Electricity

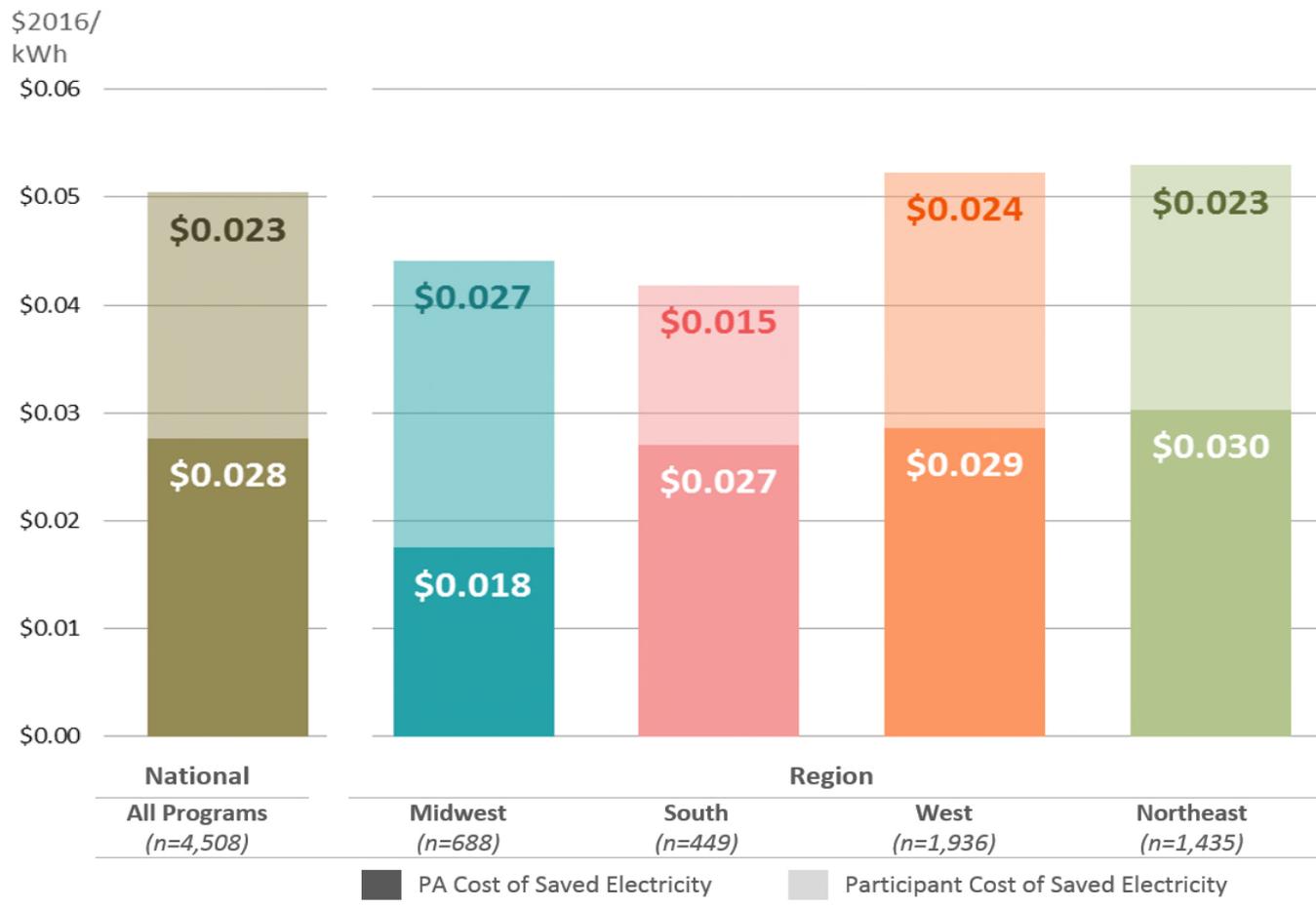
# Total Cost of Saving Electricity: National Results (2009-2015)

- Savings-weighted average Total CSE: \$0.05/kWh for 67 program administrators in 27 states
- Residential programs: \$0.039/kWh (lowest-cost sector); low-income programs: \$0.145/kWh
- C&I programs: \$0.055/kWh

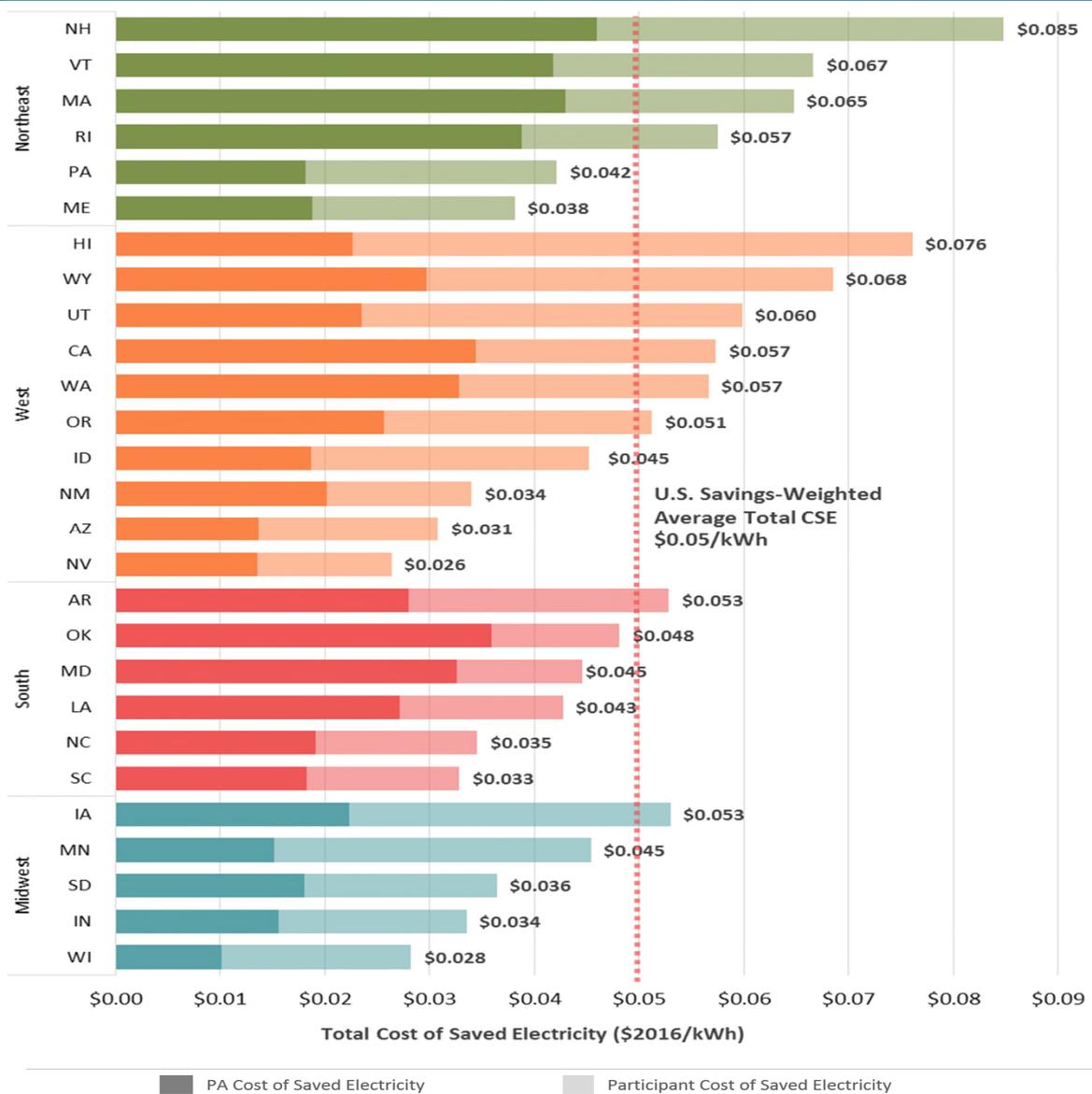


# Total Cost of Saving Electricity: Regional Results

- Average Total CSE very similar in West and Northeast (~\$0.053/kWh and ~56%/44% ratio of PA to participant cost shares)
- Total CSE is similar in South and Midwest (\$0.042 vs. 0.045/kWh), but very different ratios of PA to participant costs: 40%/60% in Midwest; 65%/35% in South



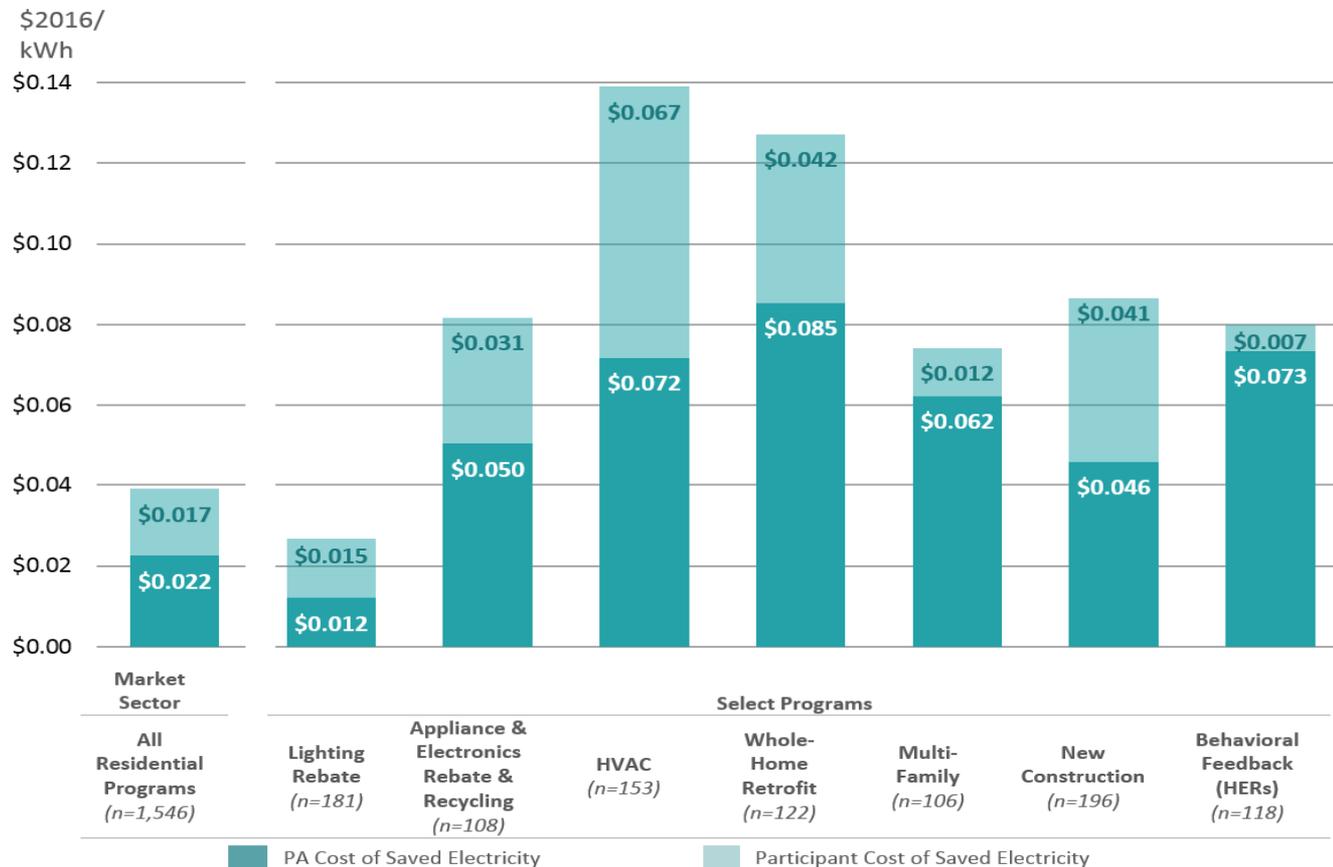
# Total Cost of Saving Electricity: State-level Results



- Total CSE varied by more than a factor of three between the lowest and highest cost states (\$0.026/kWh vs. >\$0.08/kWh)
- Total CSE <0.04/kWh for one-third of states
- Relative share of Total CSE paid by PAs vs. participants varied significantly among states
- Midwest program participants tend to pay a greater share than PAs; opposite trend in South

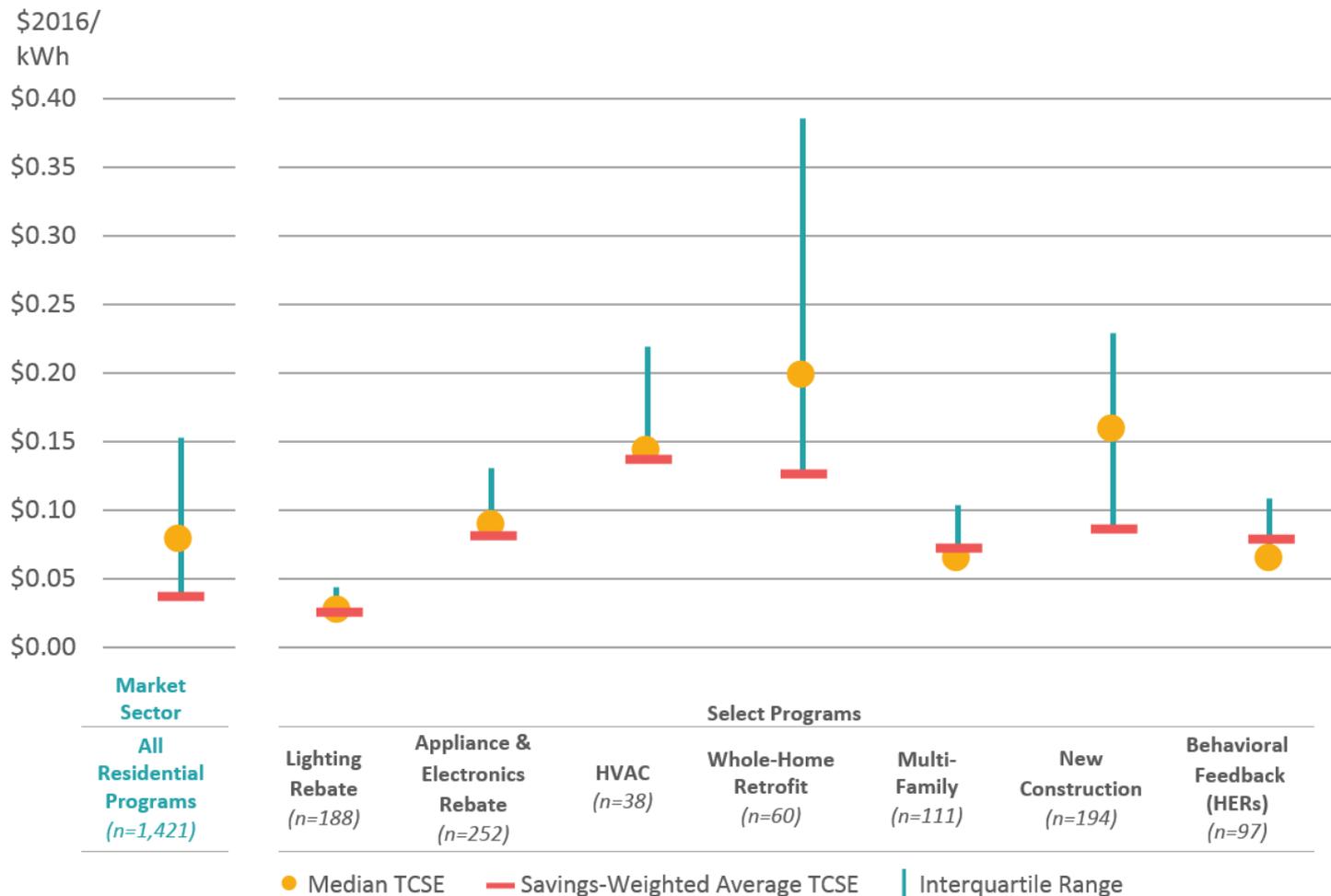
# Total Cost of Saving Electricity: Results for Select Residential Programs

- Total CSE for residential sector: \$0.039/kWh
- Nearly half of savings from lighting rebate programs (\$0.027/kWh), with participants paying 55% of costs; drove sector results
- For other programs, ranged from \$0.074/kWh for multifamily to \$0.14/kWh for HVAC



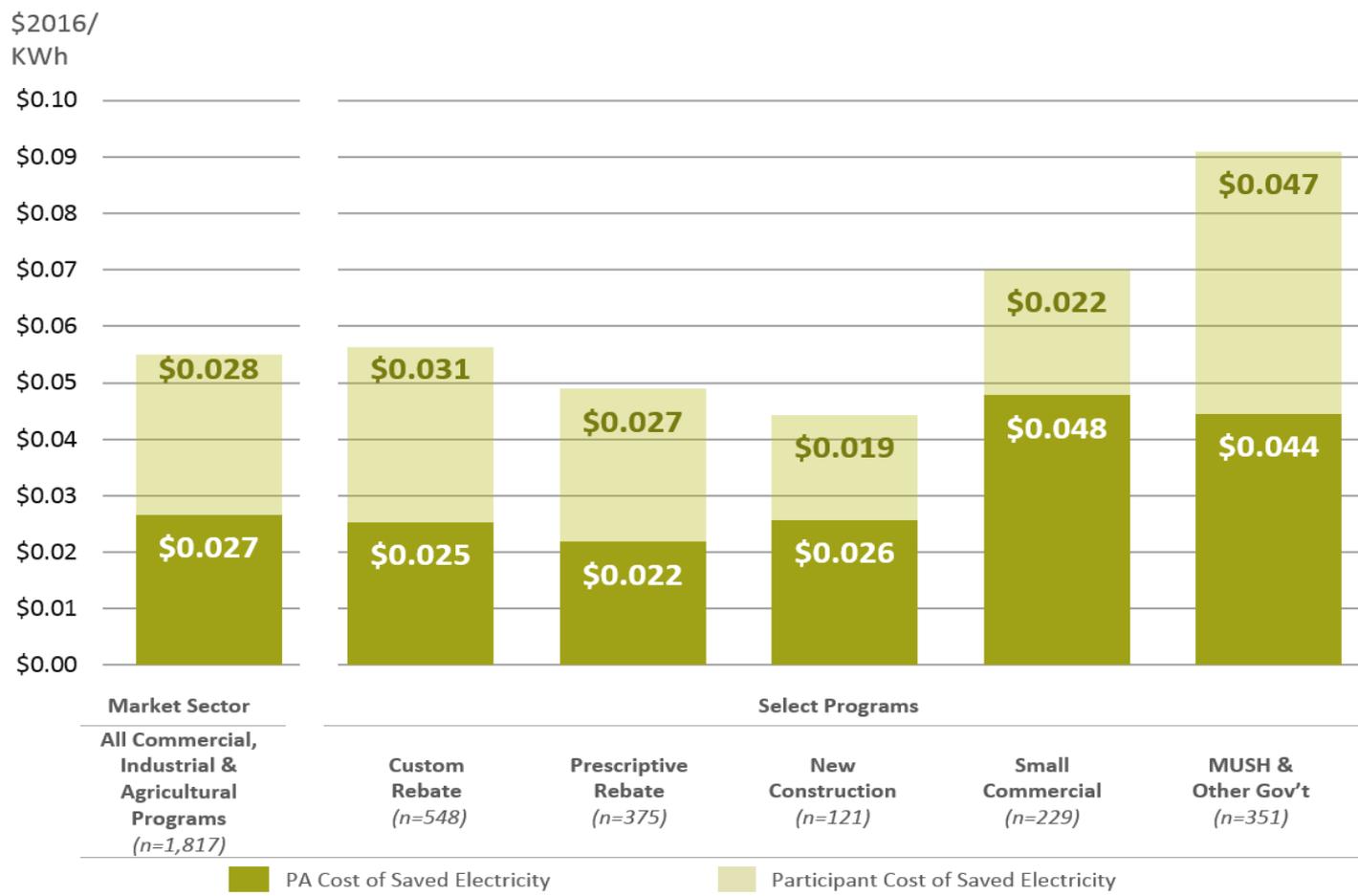
# Total Cost of Saving Electricity: Median Values and Ranges for Residential Programs

- Median value for Total CSE was much higher (\$0.077/kWh) than savings-weighted average (\$0.039/kWh) for residential programs
- Wider ranges in Total CSE for most challenging markets: whole-home retrofits, new construction and HVAC



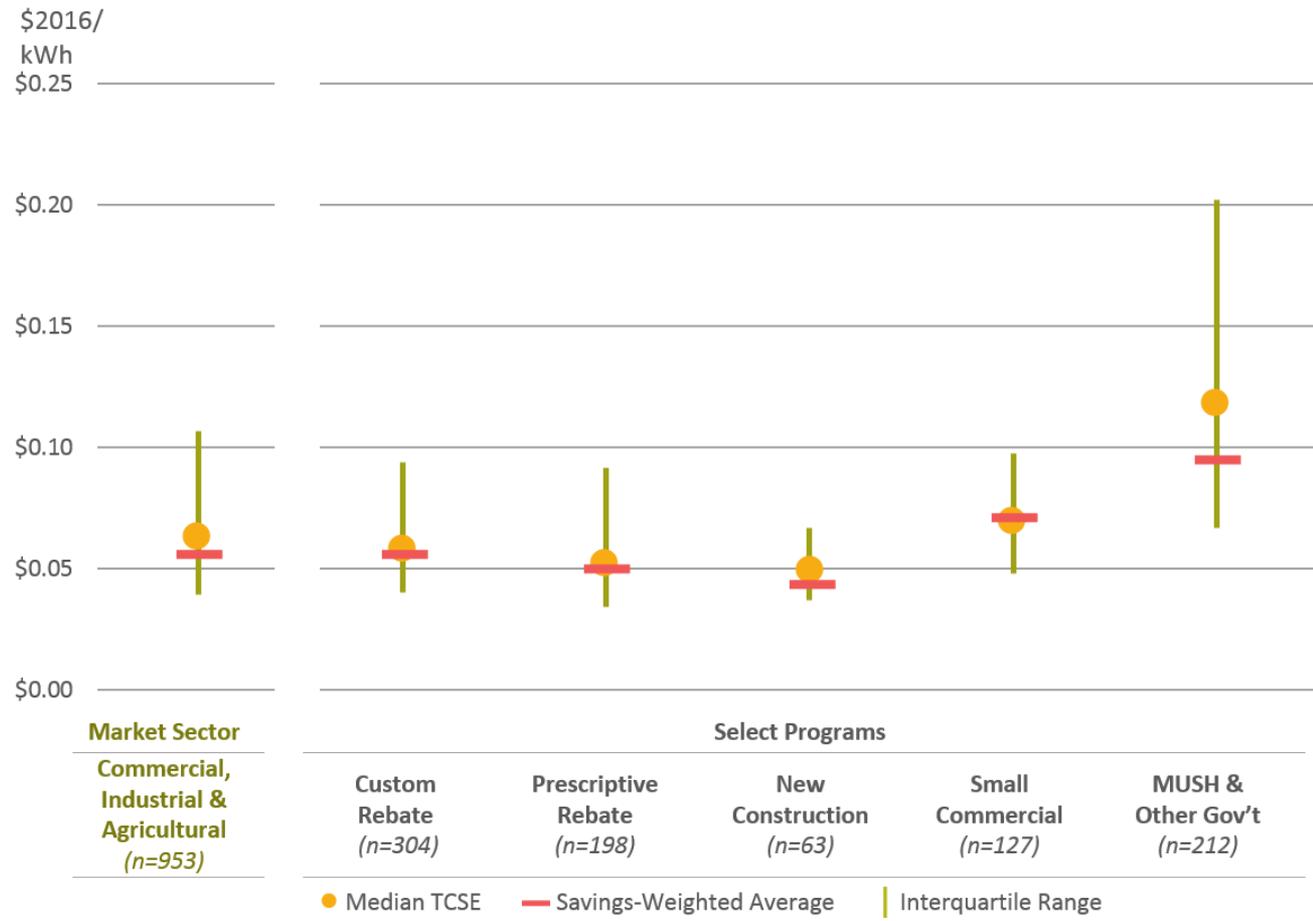
# Total Cost of Saving Electricity: Select C&I Programs

- Average Total CSE for C&I sector: \$0.055/kWh — ~40% higher than residential average
- Custom retrofits (\$0.056/kWh), prescriptive rebates (\$0.049/kWh) and new construction (\$0.045/kWh) account for 76% of C&I savings
- Participants in C&I custom programs invest moderately more than the PA — 55% vs. 45%

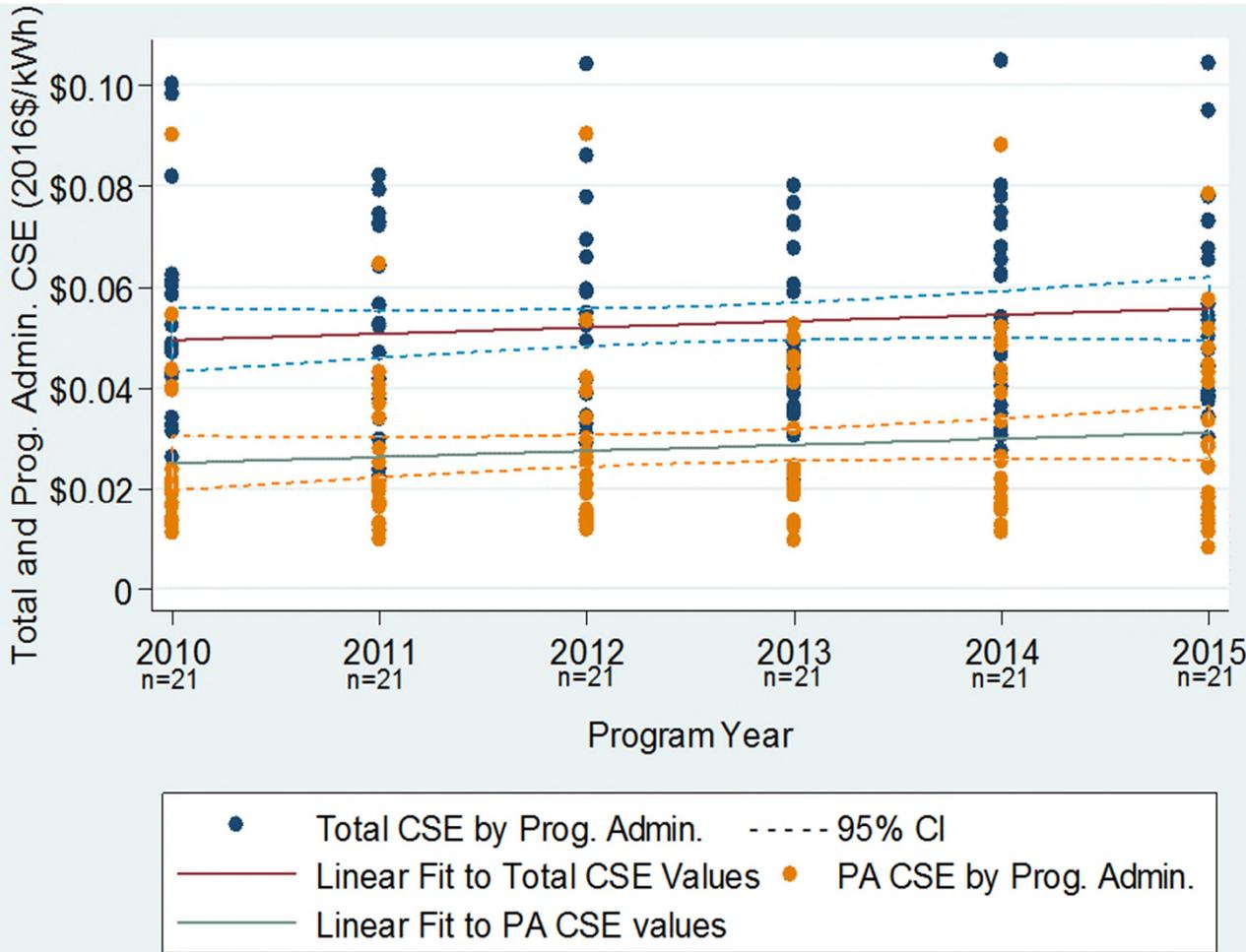


# Total Cost of Saving Electricity: Median Values and Ranges for C&I Programs

- Narrower ranges for Total CSE values for C&I programs compared to residential programs
- Closeness of medians and savings-weighted average values indicate similar performance among large and small PAs



# Trends in the Total Cost of Saving Electricity: 2010-2015



- Total CSE data available for 21 PAs between 2010 and 2015
- Very moderate growth in both Total CSE and PA CSE in this sample of PAs
- Total CSE increased by 3% per year over 2010-2015 period, driven primarily by increase in PA CSE (4.8%/year)

# Discussion: Key Findings and Potential Implications

- Cost of saving electricity remains low. Average cost to utilities is \$0.025/kWh.
- Significant variation in CSE by region, with lower CSE values in South and Midwest
- Average PA CSE values increased by 3.5% per year between 2010 and 2015 for 51 PAs with complete program data
- National “cost curve” for existing electricity efficiency programs reveals these insights:
  - Low-cost savings from residential lighting and consumer products reduce costs for the overall portfolio, accounting for 45% of lifetime savings in residential sector and 19% for national portfolio
  - Combined impact of increased market penetration of LEDs and federal lighting standards that will take effect in 2020 could reduce opportunities to acquire low-cost savings in residential lighting
  - C&I core programs — rebates for custom projects, prescriptive measures and new construction — deliver nearly half of lifetime savings. Bulk of savings come from larger C&I customers.
  - If more states allow large C&I customers to opt out of efficiency programs, PAs may rely more on savings from small and mid-size C&I customers. A shrinking C&I market may put upward pressure on CSE values in the C&I sector.
- Contraction in savings potential for lighting and core C&I savings can have large impacts on where savings come from and program cost-effectiveness, and therefore how much efficiency can be acquired.
- Behavioral feedback programs have proliferated and help achieve annual savings targets. However, their role as a significant electricity system resource is less apparent under current EM&V practices.

# Program Data Reporting: Progress and Challenges

- Progress

- Program-level reporting of electricity efficiency costs and impacts is increasing
- Granularity and quality of reporting are improving
- More PAs are reporting participant costs (54% in our database)
- More detail on program costs by cost category

- Challenges

- Consistency, completeness and transparency of program data - Still significant room for improvement
- Program average measure lifetimes - Only 27% of PAs in our database report measure lifetimes or lifetime savings, with significant variability in lifetimes for similar programs.
- Participant costs - Challenging area, more transparency needed regarding PA practices
- Net savings definitions and values
- A few utilities and states continue to withhold or redact program data.

- Full, detailed reporting is important for grid operators, utilities, and public utility commissions to increase confidence in energy efficiency as an electricity system resource and to make better informed decisions.

# Future Research Directions

- Broaden scope to include public power utilities
- Develop metrics to report on peak demand impacts
- Update the cost of saving natural gas
- Estimate CSE values based on net savings
- Improve understanding of CSE by cost category
- Compare cost performance trends of efficiency and supply-side resources

# Cost of Saving Electricity Team

## Principal Investigators



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